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The ASCA X-ray spectrum of the powerful radio galaxy 3C109

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ABSTRACT

We report the results from an ASCA X-ray observation of the powerful Broad Line Radio Galaxy, 3C109. The ASCA spectra confirm our earlier ROSAT detection of intrinsic X-ray absorption associated with the source. The absorbing material obscures a central engine of quasar-like luminosity. The luminosity is variable, having dropped by a factor of two since the ROSAT observations 4 years before. The ASCA data also provide evidence for a broad iron emission line from the source, with an intrinsic FWHM of $\sim 120,000\,\mathrm{km\,s^{-1}}$. Interpreting the line as fluorescent emission from the inner parts of an accretion disk, we can constrain the inclination of the disk to be > 35 degree, and the inner radius of the disk to be < 70 Schwarzschild radii. Our results support unified schemes for active galaxies, and demonstrate a remarkable similarity between the X-ray properties of this powerful radio source, and those of lower luminosity, Seyfert 1 galaxies.

Key words: galaxies: active – galaxies: individual: 3C109 – X-rays: galaxies

1 INTRODUCTION

Unified models of radio sources propose that radio galaxies and radio-loud quasars are basically the same population of objects, viewed at different orientations (Orr & Browne 1982; Scheuer 1987; Barthel 1989). The nucleus is only directly visible in quasars, the radio axis of which points within ~ 45 degree of the line of sight. In the case of radio galaxies the axis is closer to the plane of the Sky and the nucleus is obscured from view by material in the host galaxy, possibly in a toroidal distribution.

The powerful Broad Line Radio Galaxy (BLRG) 3C109 appears to be oriented at an intermediate angle. The nucleus is reddened, $E(B-V) \sim 0.9$, and polarized in the optical waveband (Rudy *et al.* 1984; Goodrich & Cohen 1992), suggesting that our line of sight passes through the edge of the obscuring material. The dereddened luminosity of the nucleus, $V = -26.2$ (Goodrich & Cohen 1992) identifies the source as an intrinsically luminous quasar. Obscuration is also seen at X-ray wavelengths (Allen & Fabian 1992). 3C109 was serendipitously observed with the Position Sensitive Proportional Counter (PSPC) on ROSAT in 1991 August. The PSPC spectrum exhibits soft X-ray absorption in excess of that expected from material within our own Galaxy, implying an intrinsic equivalent hydrogen column density at the redshift of the source ($z = 0.3056$; Spinrad *et al.* 1985) of $\sim 5 \times 10^{21}$ atom cm^{-2}. The intrinsic (unabsorbed) X-ray luminosity of the source ($0.1 - 2.4$ keV) determined from the PSPC data is $\sim 5 \times 10^{45}\,\mathrm{erg\,s^{-1}}$, making it one of the most X-ray luminous objects within $z \sim 0.5$; only the QSOs 3C273 and E1821+643 have higher X-ray luminosities (and 3C273 may have a significant beamed component to its X-ray emission).

We present here the results of an ASCA X-ray observation of 3C109. The ASCA data confirm the results of Allen & Fabian (1992) on excess absorption, and allow us to explore further the X-ray properties of this remarkable source. We show that 3C109 has decreased in brightness by about a factor of two since the ROSAT observations, to a flux level comparable with that observed with the Imaging Proportional Counter (IPC) on the *Einstein Observatory* in 1979 (Fabbiano et al 1984). Also, of particular interest is the detection of a strong, broad iron line in the ASCA spectra. This result implies that most of the X-ray emission from 3C109 is unbeamed. Modelling the line as fluorescent Fe K emission from an accretion disk, we are able to constrain both the inclination and inner radius of the disk. The X-ray properties of 3C109 are shown to be remarkably similar to those of many lower-power, Seyfert 1 galaxies. Throughout this paper we assume a value for the Hubble constant of H_0=50 $\mathrm{km\,s^{-1}}$ Mpc^{-1}and a cosmological deceleration parameter q_0=0.5.

2 THE ASCA OBSERVATIONS

The ASCA X-ray astronomy satellite (Tanaka, Inoue & Holt 1994) consists of four separate nested-foil telescopes, each with a dedicated X-ray detector. The detectors include two Solid-state Imaging Spectrometers or SISs (Burke *et al.* 1991, Gendreau 1995) and two Gas scintillation Imaging Spectrometers or GISs (Kohmura *et al.* 1993). The SIS instruments provide high quantum efficiency and good spectral resolution, $\Delta E/E = 0.02(E/5.9\mathrm{keV})^{-0.5}$. The GIS detectors provide a lower resolution, $\Delta E/E = 0.08(E/5.9\mathrm{keV})^{-0.5}$, but cover a larger ($\sim 50$ arcmin diameter) circular field of view.

3C109 was observed with ASCA on 1995 Aug 28-29. The SIS observations were made in the standard 1-CCD mode (Day *et al.* 1995) with the source positioned at the nominal pointing position for this mode. X-ray event lists were constructed using the standard screening criteria and data reduction techniques discussed by Day *et al.* (1995). The observations are summarized in Table 1.

Source spectra were extracted from circular regions of radius 4 arcmin (SIS0), 3.5 arcmin (SIS1) and 6 arcmin (GIS2, GIS3), respectively. For the SIS data, background spectra were extracted from regions of the chip relatively free of source counts. For the GIS data, background spectra were extracted from circular regions, the same size as the source regions, and at similar distance from the optical axes of the telescopes.

Spectral analysis was carried out using the XSPEC spectral fitting package (Shafer *et al.* 1991). For the SIS data, the 1994 Nov 9 version of the SIS response matrices were used. For the GIS data the 1995 Mar 6 response matrices were used. The spectra were binned to have a minimum of 20 counts per Pulse Height Analysis (PHA) channel, thereby allowing χ^2 statistics to be used. In general, best-fit parameter values and confidence limits quoted in the text are the results from simultaneous fits to all 4 ASCA data sets, with the normalization of the power-law continuum allowed to vary independently for each data set.

3 RESULTS

3.1 Confirmation of excess X-ray absorption in 3C109

The principal result of the ROSAT PSPC observation of 3C109 (Allen & Fabian 1992) was the detection of X-ray absorption in excess of the Galactic value determined from 21 cm HI observations. The ASCA data allow us to verify and expand upon this result.

The ASCA data were first examined using a simple absorbed power law model. This allows direct comparison with the results of Allen & Fabian (1992). The free parameters in the fits were the column density of the absorbing material, N_{H}, the photon index of the power law emission, Γ, (both parameters were forced to take the same value in all 4 ASCA data sets) and the normalizations, A_1, of the power-law emission. (Due to the range of source extraction regions used, and known systematic differences in the flux calibration of the different ASCA detectors, the value of A_1 was allowed to vary independently for each data set). The best fit parameter values and 90 per cent ($\Delta\chi^2 = 2.71$) confi-

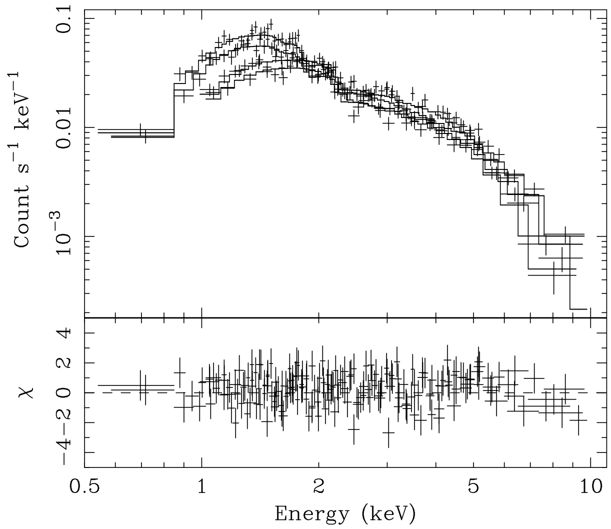

Figure 1. (Upper panel) The SIS and GIS spectra of 3C109 with the best fitting absorbed power-law model (Model A) overlaid. (Lower panel) The residuals to the fit in units of χ. (For plotting purposes the data have been rebinned along the energy axis by a factor 7.)

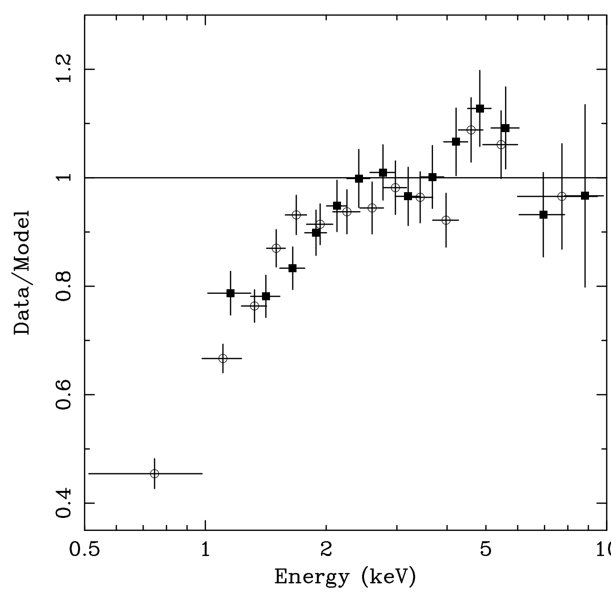

Figure 2. (Upper panel) The ratio of data to model, where the model is the best-fit Model A, but with the absorption reset to the Galactic value (assumed to be 3×10^{21} atom cm^{-2}). Note the large negative residuals at energies below 2 keV which are due to the excess absorption, and the evidence for a broad, redshifted emission line feature at ~ 5 keV. For plotting purposes, the SIS (open circles) and GIS (filled squares) data sets have been averaged together and binned by a factor of 20 along the energy axis.

Table 1. Observation summary

Instrument	Observation Date	Exposure (ks)
ASCA SIS0	1995 Aug 28/29	36.0
ASCA SIS1	””	35.0
ASCA GIS2	””	35.0
ASCA GIS3	””	35.0
ROSAT PSPC	1991 Aug 30	22.1
Einstein IPC	1979 Mar 7	1.86

Notes: X-ray observations of 3C109. Exposure times are for the final X-ray event lists after standard screening criteria and corrections have been applied.

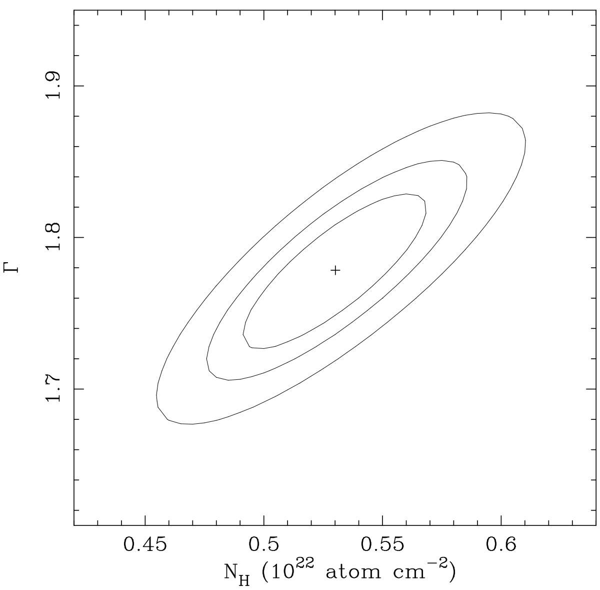

Figure 3. Joint confidence contours on the photon index and total column density, determined with spectral Model A (Table 3). Contours mark the regions of 68, 90 and 99 per cent confidence ($\Delta\chi^2 = 2.30, 4.61$ and 9.21 respectively).

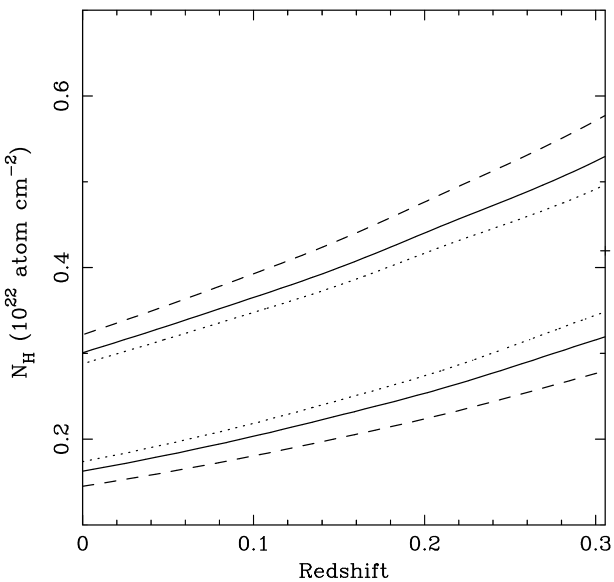

Figure 4. Joint confidence contours (68, 90 and 99 per cent confidence) on the column density and redshift of the excess absorber in 3C109 (using spectral Model B).

dence limits obtained with this simple model are presented in Table 3 (Model A).

The SIS and GIS spectra with their best-fitting models (Model A) overlaid are plotted in Fig. 1. For illustrative purposes, in Fig. 2 we show the best fit model with the column density reset to the Galactic value (assumed to be 3.0×10^{21} atom cm^{-2}). Note the large negative residuals at energies, $E < 2$ keV, which demonstrate the effects of the excess absorption, and the broad positive residual at $E \sim 5$ keV, which will be discussed in more detail in Section 3.3.

The ASCA results clearly confirm the PSPC result on excess absorption in the X-ray spectrum of 3C109. Assuming that the absorber lies at zero redshift we determine a total column density along the line of sight of $5.30 \pm 0.42 \times 10^{21}$ atom cm^{-2}(90 per cent confidence limits). This is in good agreement with the PSPC result of $4.2^{+1.9}_{-1.6} \times 10^{21}$ atom cm^{-2}. The ASCA result on the photon index, $\Gamma = 1.78^{+0.05}_{-0.06}$, is also in excellent agreement with the PSPC result of $1.78^{+0.85}_{-0.76}$, although is more firmly constrained. The joint confidence contours on Γ and $N_{\rm H}$ are plotted in Fig. 3.

We have examined the constraints the ASCA spectra can place on the redshift of the excess absorbing material. The Galactic column density along the line of sight to 3C109, determined from 21cm observations, is 1.46×10^{21} atom cm^{-2}(Jahoda *et al.* 1985; Stark *et al.* 1992), although Johnstone *et al.* (1992) suggest a slightly higher value of $\sim 2.0 \times 10^{21}$ atom cm^{-2}, and Allen & Fabian (1996) infer a value of $\sim 3.0 \times 10^{21}$ atom cm^{-2} from X-ray studies of the nearby cluster of galaxies Abell 478. Modelling the ASCA spectra with a two-component absorber, with a Galactic (zero-redshift) column density of 3.0×10^{21} atom

cm^{-2}, and a component with variable column density and redshift, we obtain the joint confidence contours on the redshift and column density of the excess absorption plotted in Fig. 4. The best-fit parameter values and 90 per cent confidence limits for the two-component absorption model (Model B) are also summarized in Table 3.

3.2 Variation of the X-ray luminosity

The flux measurements for 3C109 are summarized in Table 2. Results are presented for both SIS instruments in the $1.0 - 2.0$ and $2.0 - 10.0$ keV (observer frame) energy bands. (The GIS detectors provide less accurate flux estimates). Also listed in Table 2 are the fluxes observed with the ROSAT PSPC in August 1991 and the IPC on Einstein Observatory in March 1979. We see that in the overlapping $1.0 - 2.0$ keV energy band, the brightness of 3C109 has decreased by a factor ~ 2 since 1991. The flux determination from the ASCA data is now consistent with that inferred from the IPC observation in 1979.

Also listed in Table 2 are the intrinsic (absorption-corrected) X-ray luminosities of the source inferred from the observations. (Here the energy bands correspond to the rest-frame of the source). The absorption-corrected $2 - 10$ keV luminosity inferred from the ASCA spectra is 2.1×10^{45} $\mathrm{erg\,s^{-1}}$. (We assume that during the Einstein IPC observations the source had the same spectral shape as determined from the ASCA observations.)

3C109 has also been observed to vary at near-infrared wavelengths. Rudy *et al.* (1984) found variations of a factor ~ 2 in the J band over a five year span from 1978 to 1983. Elvis *et al.* (1984) similarly reported variations in the J, H and K bands of $\sim$ 50 per cent (in the same sense) on a timescale of 2–3 years between 1980 and 1983.

3.3 Discovery of a broad iron line

The residuals to the fits with the simple power-law models, presented in Figs. 1 and 2, exhibit an excess of counts in a line-like feature at $E \sim 5.0$ keV. X-ray observations of Seyfert galaxies (Nandra & Pounds 1994 and references therein) show that many such sources exhibit a strong emission line at $E \sim 6.40$ keV (in the rest frame of the object). This is normally attributed to fluorescent Fe K emission from cold material irradiated by the nucleus.

We find that the fit to the ASCA data for 3C109 is significantly improved by the introduction of a Gaussian line at $E \sim 5$ keV ($\Delta\chi^2 = 9.2$ for 3 extra fit parameters; an F-test indicates this to be significant at the 97 per cent level.) The best-fit line energy is $5.09^{+0.44}_{-0.38}$ keV (corresponding to $6.61^{+0.57}_{-0.50}$ keV in the rest frame of the source. Note that if a fixed rest-energy of 6.4 keV is assumed, the introduction of the Gaussian component becomes significant at the ~ 99 per cent confidence level). The data also indicate that the line is broad, with a 1 sigma width of $0.65^{+0.81}_{-0.36}$ keV. The equivalent width of the line is 300^{+600}_{-200} eV. The width and energy of the line suggest that it is due to fluorescence from a rapidly rotating accretion disk – as is thought to be the case in lower luminosity Seyfert galaxies (Tanaka *et al.* 1995; Fabian *et al.* 1995). The best fitting parameters and confidence limits for the power-law plus Gaussian model (Model C) are summarized in Table 3. Note that the emission feature is not well-modelled by the introduction of an absorption edge at higher energies [the introduction of an edge into the simple absorbed power-law model (Model A) does not significantly improve the fit]. Note also that the measured line flux is not significantly affected by the small systematic bump in the XRT response at $E \sim 5.5$ keV (which produces a narrow, positive residual with a flux of a few per cent of the continuum flux at that energy).

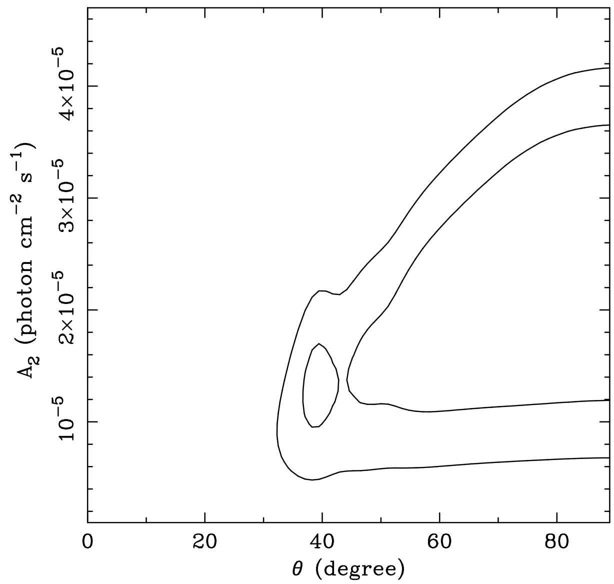

Figure 5. Joint confidence contours (68, and 90 per cent confidence) on the normalization, A_2, and inclination, θ, of the disk line using spectral Model D (following Fabian *et al.* 1989).

3.4 Modelling the line as a diskline

Although the simple Gaussian model provides a reasonable description of the 5.0 keV emission feature, the ASCA data suggest that the line profile is probably more complex. Using two Gaussian components to model the line profile, we obtain the best fit for a broad component with a rest energy consistent with 6.4 keV, and a narrow component with an energy 6.8 ± 0.1 keV (in the rest-frame of the source). These results are similar to those obtained for nearby, lower-luminosity Seyfert galaxies (*e.g.* Mushotzky et al 1995; Tanaka et al 1995; Iwasawa *et al.* 1996) where the line emission is thought to originate from the inner regions of an accretion disk surrounding a central, massive black hole (Fabian *et al.* 1989).

We have therefore modelled the broad line in 3C109 using the Fabian *et al.* (1989) model for line emission from a relativistic accretion disk. The rest-energy of the line (in the emitted frame) was fixed at 6.40 keV, the energy appropriate for Fe K fluorescence from cold material. (The effects of cosmological redshift were incorporated into the model.) The accretion disk was assumed to extend over radii from 3 to 500 Schwarzschild radii (hereafter $R_{\rm s}$) and cover a solid angle of 2π steradians. The emissivity was assumed to follow a standard disk radiation law. Only the disk inclination and

Table 2. X-ray flux of 3C109

Instrument	Date	F_X		L_X	
		2-10 keV	1-2 keV	2-10 keV	1-2 keV
ASCA SIS0	1995 Aug 28/29	48.5 ± 1.6	9.50 ± 0.23	21.4 ± 0.3	$6.69^{+0.76}_{-0.71}$
ASCA SIS1	””	46.3 ± 2.1	9.76 ± 0.32	21.3 ± 0.3	$7.68^{+1.10}_{-0.89}$
		0.1-2.4 keV	1-2 keV	0.1-2.4 keV	1-2 keV
ROSAT PSPC	1991 Aug 30	28.9 ± 2.6	18.2 ± 0.7	45^{+147}_{-25}	$12.1^{+6.3}_{-3.5}$
		0.5-3.0 keV	1-2 keV	0.5-3.0 keV	1-2 keV
Einstein IPC	1979 Mar 7	20 ± 6	8.3 ± 2.5	16.5 ± 5.0	6.2 ± 1.9

Notes: The X-ray flux and luminosity of 3C109 measured with ASCA, ROSAT and the Einstein Observatory. Fluxes are in units of 10^{-13} erg cm^{-2}s^{-1} and are defined in the rest frame of the observer. Luminosities are in 10^{44} erg s^{-1}, are absorption corrected, and are quoted in the rest frame of the source. Errors are 90 per cent ($\Delta\chi^2 = 2.71$) confidence limits.

line strength were free parameters in the fit. The best fit parameters and 90 per cent confidence limits obtained with the diskline model are listed in Table 3 (Model D). The introduction of the diskline component significantly improves the fit to the ASCA data with respect to the power-law model ($\Delta\chi^2 = 8.9$ for 2 extra fit parameters, which an F-test indicates to be significant at the 99 per cent confidence level).

In Fig. 5 we show the joint confidence contours on the inclination of the disk, θ, versus the line strength, A_2. The 90 per cent ($\Delta\chi^2 = 2.71$) constraint on the inclination is $\theta > 35$ degree. We have also examined the constraints that may be placed on the inner radius, r_{in}, of the accretion disk with the diskline model. The data were re-fitted with r_{in} included as a free parameter. The preferred value for r_{in} is 3 $R_{\rm s}$, with a 90 per cent confidence upper limit of $70R_{\rm s}$. (Note that for an ionized disk, with a rest-energy for the line of 6.7 keV, the inclination is constrained to $\theta > 18$ degree.)

The effects of introducing a further, flatter power-law component into the fits, such as may be required to account for reflected emission from the illuminated face of an accretion disk, or synchrotron self-Compton emission from within a jet, were also examined. The introduction of a flatter power-law component does not significantly improve the fits. However, the ASCA spectra permit (with no significant change in χ^2) the inclusion of a continuum spectrum appropriate for reflection from a cold disk, subtending a solid angle of 2π steradians to the primary X-ray source, oriented at any inclination consistent with the results from the diskline fits.

4 DISCUSSION

The ASCA results on excess X-ray absorption in 3C109 confirm and refine the earlier ROSAT results (Allen & Fabian 1992). The ASCA data show (under the assumption that all of the absorbing material lies at zero redshift) that the X-ray spectrum of the source is absorbed by a total column density of $5.30^{+0.42}_{-0.42} \times 10^{21}$ atom cm^{-2} (Model A). This compares to a Galactic column density of $\sim 3.0 \times 10^{21}$ atom cm^{-2}(Allen & Fabian 1996). If we instead assume that the excess absorption, over and above the Galactic value, is due to material at the redshift of 3C109, we determine an intrinsic column density of $4.20^{+0.83}_{-0.78} \times 10^{21}$ atom cm^{-2}. Note that these results assume solar abundances in the absorbing material (Morrison & McCammon 1983).

The X-ray absorption measurements are in good agreement with optical results on the polarization and intrinsic reddening of the source. Goodrich & Cohen (1992) determine an intrinsic continuum reddening of $E(B-V) \sim 0.9$, in addition to an assumed Galactic reddening of $E(B-V) = 0.27$. Using the standard (Galactic) relationship between $E(B-V)$ and X-ray column density, $N_{\rm H}/E(B-V) = 5.8 \times 10^{21}$ atom cm^{-2} mag^{-1} (Bohlin, Savage & Drake 1978), the total reddening observed, $E(B-V) \sim 1.2$, implies a total X-ray column density (Galactic plus intrinsic) of $\sim 7.0 \times 10^{21}$ atom cm^{-2}. This result is similar to the X-ray column density inferred from the ASCA spectra using model B and confirms the presence of significant intrinsic absorption at the source. Note that this result also suggests that the dust-to-gas ratio in 3C109 is similar to that in our own Galaxy.

Further constraints on the distribution of the absorbing gas are obtained from the optical emission-line data presented by Goodrich & Cohen (1992). In the narrow line region (NLR), the observed Blamer decrement of Hα/Hβ = 5.8 implies (for an assumed recombination ratio of 3.2) an $E(B-V)$ value ~ 0.48. Using the relationship of Bohlin, Savage & Drake (1978) this implies an X-ray column density to the NLR of $\sim 2.8 \times 10^{21}$ atom cm^{-2}, in good agreement with the Galactic column density of $\sim 3.0 \times 10^{21}$ atom cm^{-2} determined by Allen & Fabian (1996) and adopted in the X-ray analysis presented here. The Balmer decrement in the broad line region (BLR) is very steep (Hα/Hβ = 13.2). Although this value cannot be reliably used to infer the extinction to the BLR, the intrinsic line ratio is unlikely to be above 5, suggesting a total line-of sight reddening to the BLR of $E(B-V) \gtrsim 0.8$. Thus, the BLR is likely to be intrinsically reddened by $E(B-V) \gtrsim 0.3$. The optical emission line results are therefore consistent with the two-component absorber model (B), with the column density of the intrinsic absorber being comparable with the Galactic component.

Table 3. Results of the spectral analysis

MODEL	PARAMETERS						
A	Γ	A_1	$N_{\rm H}$	—	—	—	χ^2/DOF
wabs (pow)	$1.78^{+0.05}_{-0.06}$	$1.38^{+0.10}_{-0.10}$	$0.530^{+0.042}_{-0.042}$	—	—	—	638.9/633
B	Γ	A_1	$N_{\rm H}$	$N_{\rm H}(z)$	—	—	χ^2/DOF
wabs zwabs (pow)	$1.77^{+0.05}_{-0.06}$	$1.35^{+0.10}_{-0.09}$	0.300	$0.420^{+0.083}_{-0.078}$	—	—	641.6/633
C	Γ	A_1	$N_{\rm H}$	E	σ	A_2	χ^2/DOF
wabs (pow+gau)	$1.86^{+0.12}_{-0.08}$	$1.47^{+0.16}_{-0.12}$	$0.558^{+0.056}_{-0.046}$	$5.09^{+0.44}_{-0.38}$	$0.65^{+0.81}_{-0.36}$	$2.1^{+4.3}_{-1.3}$	629.7/630
D	Γ	A_1	$N_{\rm H}$	E	θ	A_2	χ^2/DOF
wabs (pow+diskline)	$1.87^{+0.08}_{-0.08}$	$1.48^{+0.14}_{-0.13}$	$0.561^{+0.052}_{-0.046}$	6.40	$90^{+0.0}_{-55}$	$2.4^{+1.4}_{-1.4}$	630.0/631

Notes: A summary of best-fit parameters and 90 per cent ($\Delta\chi^2 = 2.71$) confidence limits from the spectral analysis of the ASCA data. Results are shown for four different models fitted simultaneously to the data for all four ASCA detectors. Γ is the photon index of the underlying power-law continuum from the source. A_1 is the normalization of the power law component in the S0 detector in 10^{-3} photon keV^{-1}cm^{-2}s^{-1} at 1 keV. $N_{\rm H}$ is the equivalent hydrogen column density in 10^{22} atom cm^{-2}at zero redshift. In Model B, $N_{\rm H}$(z) is the best-fit intrinsic column density at the source for an assumed Galactic column density of 0.3×10^{22} atom cm^{-2}. In Model C, E is the energy of the Gaussian emission line in the frame of the observer, σ is the one-sigma line width in keV, and A_2 is the line strength in 10^{-5}photon cm^{-2}s^{-1}. In Model D, E is the rest-energy of the line in the emitted frame, θ is the inclination of the disk in degree, and A_2 is again the line strength in 10^{-5}photon cm^{-2}s^{-1}.

3C109 is the most powerful object in which a strong broad iron line has been resolved to date. Several more luminous quasars observed with ASCA do not show any iron emission or reflection features (Nandra et al 1995). The next most luminous object with a confirmed broad line is 3C390.3 (Eracleous, Halpern & Livio 1996) which is about 10 times less luminous in both the X-ray and radio bands than 3C109. The equivalent widths of the lines in both objects are $\sim$ 300 eV and therefore similar to those observed in lower-luminosity Seyferts. This argues against any X-ray 'Baldwin effect' (as proposed by Iwasawa & Taniguchi 1993).

The line emission from 3C109 is most plausibly due to fluorescence from the innermost regions of an accretion disc around a central black hole (Fabian et al 1995). Our results constrain the inner radius of the accretion disk to be $< 70R_{\rm s}$ and the inclination of the disk to be > 35 degree. The strong iron line observed in 3C109, and the lack of evidence for a synchrotron self-Compton continuum in the X-ray spectrum, both suggest that little radiation from the jet is beamed into our line of sight.

The inclination determined from the ASCA data is larger than the angle proposed by Giovannini *et al.* (1994) based on the jet/core flux ratio of the source ($\theta < 34$ degree). However, the jet/core flux arguments are based on simple assumptions about the average orientation angles for radio galaxies and neglect environmental effects. The conflict with the X-ray results may indicate that the situation is more complicated. Giovannini *et al.* (1994) also present constraints on the inclination from VLBI observations of the jet/counterjet ratio, which require $\theta < 56$ degree. The VLBI constraint, together with the ASCA X-ray constraint, then suggests $35 < \theta < 56$ degree.

Our results on 3C109 are in good agreement with the unification schemes for radio sources and illustrate the power of X-ray observations for examining such models. The preferred, intermediate inclination angle for the disk in 3C109 is in good agreement with the results on X-ray absorption, polarization and optical reddening of the source, all of which suggest that our line of sight to the nucleus passes closes to the edge of the surrounding molecular torus. The results on the broad iron line reveal a striking similarity between the X-ray properties of 3C109 and those of lower power, Seyfert 1 galaxies (Mushotzky et al 1995; Tanaka et al 1995; Iwasawa et al 1996). This is despite the fact that the X-ray power of 3C109 exceeds that of a typical Seyfert galaxy by $\sim$ 2 orders of magnitude.

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